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Patapsco Sewershed Evaluation Study Plan
Project #1041

Baseline Analysis and Capacity Assessment Report

Sanitary Sewer Overflow Consent Decree
Civil Action No. JFM-02-1524

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Baseline Analysis and Capacity Assessment Report

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EXECUTIVE SUMMARY

As part of Baltimore City Project No. 1041, Whitman, Requardt & Associates, LLP (WR&A) has developed a calibrated hydraulic model of the Patapsco Sewershed within the City of Baltimore. This report summarizes the analysis of the collection system under baseline and future conditions using this model. This report identifies areas that experience surcharges or overflows during seven different design storms, for both baseline and future flow conditions.

The modeling software selected for this project is InfoWorks CS, by Wallingford Software, Ltd. As of the date of this report, the most recent version is InfoWorks CS 10.0.3. As required by the CD, the hydraulic model includes all force mains, major gravity lines equal to or greater than 10-inches in diameter, 8-inch sewers that connect between 10-inch and greater sewers or are necessary for hydraulic continuity, and related appurtenances. The model also includes all manholes, junctions, and structures along modeled sewer lines and all control structures existing in the system. Of the approximately 270,000 feet of sanitary sewers in the Patapsco Sewershed evaluation, there are over 80,000 feet of sewers 10-inches and larger included in the hydraulic model. In addition, there are approximately 3500 feet of critical 8-inch sewers included in the model network. Two pumping stations are included in the model: Brooklyn, and the Patapsco Wastewater Treatment Plant (WWTP) Low Level Influent Pumping Station. There are four sources of flow from Anne Arundel County, three of which are metered. The wetwell level at the Patapsco WWTP Low Level pumping station serves as the outfall boundary condition for the model.

For the sewersheds being studied as part of the Consent Decree, baseline conditions were defined by the City to be the conditions in effect after the completion of Paragraph 8 projects in the sewershed. In addition, any project in the City's Capital Improvement Plan (CIP) that will be completed by 2016 which affects the hydraulic capacity of the wastewater collection and transmission system is to be included in the baseline conditions model. Unlike other sewersheds in the City, the Patapsco sewershed did not have any so-called Paragraph 8 projects. This refers to Paragraph 8 of the City's Consent Decree with EPA and MDE, which required a number of design and construction projects to eliminate sanitary sewer overflows into the waters of the State. Since there were no Paragraph 8 projects in the Patapsco sewershed, the sanitary sewer system as it existed at the time of the flow monitoring program (May, 2006 to May, 2007), plus CIP projects that affect the capacity of the sewershed, represent the baseline conditions.

The Consent Decree further states that the future condition of the sewershed shall be modeled based on population projections and a prediction of sewer condition deterioration. The City has decided that future population estimates will be based on Year 2025 projections to provide consistency with the Consent Decree for Baltimore County. Future population estimates are based on demographic projections determined by the Baltimore Metropolitan Council, which consists of Baltimore City and the five surrounding Counties, including Baltimore, Howard and Anne Arundel Counties, which contribute wastewater flows to the City. The hydraulic impact due to pipe deterioration has been represented in the model by increasing the amount of dry weather groundwater infiltration by 10 percent between the baseline and future condition.

The calibrated hydraulic model has been run for both dry and wet weather flows to identify areas of the Patapsco collection system which lack adequate capacity to handle the projected flows from the various storm events. The wet weather flows have been modeled using the seven design storm events prescribed by the City of Baltimore. These are: the 3 month storm with a duration equal to the time of concentration for the sewershed; and the 1, 2, 5, 10, 15, and 20 year, 24 hour duration storms.

A capacity assessment of the baseline and future conditions during dry weather was completed. The level of wastewater in each pipe was determined and is graphically depicted on maps included in this report, which show the percent full for modeled sewers as well as sewers experiencing surcharging. There are no overflows in the system during dry weather. There are four sewer segments where surcharged conditions are predicted for the peak dry weather flows under future conditions.

One of the requirements of the Consent Decree is to run a Return Period Analysis (RPA) for the seven design storms for both the baseline and future conditions. The results of the baseline and future flooding RPA's are depicted on maps included in this report.

Capacity analyses were also performed for the Brooklyn and Patapsco WWTP Low level Influent pumping stations. At the Brooklyn Pumping Station, there are three wastewater pumps. Two are rated at 3600 gallons per minute (gpm), or 5.18 million gallons per day (mgd) and one, a standby, is 5700 gpm, or 8.21 mgd. At the Patapsco WWTP, flow enters the Pump and Blower (P and B) Building, where there are four 8600 gpm (12.38 mgd) raw wastewater pumps, one of which is in standby mode. Model simulations were run during dry and wet weather events with the back-up pump at each station off line. In addition, simulations were run with all pumps in service. At the Brooklyn Pumping Station, the 10, 15 and 20 year storms cause the wetwell to overflow under baseline and future conditions with the backup pump off line; however, these overflows are confined to the station and do not result in additional manhole flooding. At the Patapsco WWTP Low level Pumping Station, there is a station overflow during the 20 year storm with one pump off line; again, this overflow is confined to the station and does not result in additional manhole flooding. Additional details regarding the pumping station capacity analyses are included in the report.

Another requirement of the Consent Decree is to identify and map all components of the wastewater collection system that restrict the flow of wastewater, or cause or contribute, or are likely to cause or contribute to overflows from the collection system. The results of this analysis for baseline and future conditions are shown on maps included in this report.

Under dry weather conditions, there are no overflows in the Patapsco Sewershed, nor are there any overflows during the 3 month storm event. Beginning at the 1 year storm event, for both baseline and future conditions, sanitary sewer overflows (SSOs) start to occur based on the RPA. These are few in number and relatively small in volume. Estimates of the total SSO volumes and the manhole locations of each SSO caused by the various design storms are provided in the report.

Eighteen manholes exhibited overflows based on the RPA of the twenty year design storm event under baseline conditions. When modeling future conditions, a total of twenty manholes overflow during the twenty year design storm event, with 184,300 gallons of additional overflow volume.

1.0 PROJECT DESCRIPTION

1.1 Project Location

The Patapsco sewershed is located at the far southern end of Baltimore City, south and southeast of the Patapsco River at the boundary between the City and Anne Arundel and Baltimore Counties. The Patapsco sewershed consists of approximately 5,000 acres of land with 1303 manholes or other wastewater structures, and 268,285 feet of sanitary sewers that drain to the Patapsco Wastewater Treatment Plant. Of that total, 12,975 feet of sewers lie in flow monitoring basin PA13, which drains to the Westport Pumping Station, which then discharges into the Southwest Diversion. The sewers and manholes in PA13 are not a part of the Patapsco Sewershed evaluation, but are included in the Gywnn's Falls Sewershed Study, Project #1032. The sanitary sewers in the Patapsco sewershed range in size from 4 to 64 inches. The largest sewer is the central trunk sewer, known as the Patapsco Interceptor. The interceptor receives pumped flow from the Brooklyn Pumping Station, just east of Hanover Street and north of Frankfurst Avenue, and flows southeasterly to the Patapsco Wastewater Treatment Plant (WWTP) at Wagner's Point. The interceptor is a cast in place concrete and tile box sewer, which is square, rectangular, or arched in cross section, and ranges in size from 24 by 24 inches to 54 by 64 inches. See Figure 1.1 for an overview of the sewershed and its major sewer lines and features.

There are two major pumping stations located within the sewershed, the Patapsco WWTP Influent Pumping Station and the Brooklyn Pumping Station. The Patapsco influent pumping station lifts wastewater from the so called low level system into the treatment facility. All of the flow in the Patapsco Interceptor, as measured by trunk sewer flow monitor TSPA03, as well as flow from a 24-inch sewer in Asiatic Avenue, measured by flow monitor PA01, enters the Patapsco WWTP and is pumped by the influent pumps in the Pump and Blower Building to the treatment processes. The Brooklyn pumping station receives flow from the Cherry Hill neighborhood to the west, through a 30-inch influent sewer, measured by flow monitor PA10, that crosses the Patapsco River, as well as from the southwestern section of Brooklyn, through a 27-inch influent sewer in Hanover Street, which is measured by flow monitor PA09. There is also a small pumping station at Hawkin's Point that currently pumps only leachate collected from the Quarantine Road Landfill through a 10/12-inch force main into the Patapsco sewerage system at Benhill and Curtis Avenues. In the future, a new pumping station may collect and pump domestic wastewater from proposed development in the Hawkin's Point area. The Patapsco Plant receives most of its wastewater flow from the Southwest Diversion, which is an 84-102 inch pressure sewer that traverses the entire width of the Patapsco sewershed. The Southwest Diversion contains flow transferred from the Gywnn's Falls sewershed in southwestern Baltimore City, as well as flow from Baltimore and Howard Counties. Although the Southwest Diversion passes through the Patapsco sewershed, it does not intercept any wastewater generated in the sewershed, with the exception of PA13, as noted above. The Patapsco sewershed also receives flow from Anne Arundel County at three metered locations along the City/County boundary, namely BPA01, BPA02 and BPA03, and an unmetered location at Church Street and Muriel Avenue. See Figure 1.2 for a schematic of the Patapsco Sewershed, including metering locations and sub-sewershed designations.

The major water bodies in the area are Curtis Bay, which borders the sewershed on the south and east, and the Patapsco River which crosses through the sewershed just north and west of the Brooklyn pumping station. The Patapsco sewershed includes the residential neighborhoods of Cherry Hill, Brooklyn, Curtis Bay and Brooklyn Manor, as well as the industrial areas of Fairfield and Wagner's Point. The industrial areas include heavy industries such as oil and chemical refineries, petroleum and chemical storage tanks, warehousing and manufacturing facilities. In addition, the CSX Curtis Bay Yard and CSX Coal and Ore piers add to the heavy industrial presence and rail activity in the sewershed. Although there are extensive industrial areas in the sewershed, there are also large tracts of residential areas. Although most of the waterfront properties are now in industrial/commercial use, redevelopment along waterfront areas could bring increased population and wastewater flows compared to the current land uses.

1.2 Flow Monitoring Basins

The Patapsco Sewershed consists of fourteen flow monitoring basins, PA01 through PA13, plus PA05A. The boundaries for each of these basins are depicted in Figure 1.3. As previously noted, PA13 drains to the Westport Pumping Station which then discharges into the Southwest Diversion. Other than the flow from PA13, the Southwest Diversion contains flow transferred from the Gywnn's Falls sewershed in southwestern Baltimore City, as well as flow from Baltimore and Howard Counties, and is not part of the Patapsco Sewershed Evaluation. Thirteen flow monitoring basins are included in this evaluation of the Patapsco sewershed, specifically PA01 through PA12, plus PA05A.

1.3 Consent Decree Requirements

A Consent Decree (CD) was agreed upon between the City of Baltimore, the United States Environmental Protection Agency and the Maryland Department of the Environment in September, 2002. As stipulated on page 32 of the CD, the hydraulic model must be capable of determining:

1. The flow capacity of each of the pumping stations in the collection system;
2. The flow capacity of each pumping station with its back-up pump out-of-service;
3. Peak flows for each pumping station during storm events of a magnitude up to 20 years;
4. Likelihood and location of overflow(s) within a service area under high flow conditions, including pumping station service areas where the pumping station's back-up pump is out-of-service, considering available wet well capacity, off-line storage capacity and normal in-line storage capacity.

Paragraph 9.C of the CD states that it will be necessary to determine the range of storm events for which the collection system in its existing condition can convey peak flows without the occurrence of sanitary sewer overflows. As part of the analyses, all modeled components of the collection system that cause or contribute to flow restrictions or that have the potential to cause or contribute to overflows are identified.

1.4 Guidelines and Requirements

As specified in the Consent Decree and by the City of Baltimore, after the hydraulic model has been calibrated and approved by the Technical Program Manager, it shall be used to analyze the collection system under baseline and future conditions for seven design storms. These design storms include: the three-month storm having duration equal to the time of concentration for the sewershed; the 20-year 24-hour duration storm; and the 1, 2, 5, 10, and 15-year, 24 hour storms.

Baseline conditions were defined by the City to be the conditions in effect after the completion of Paragraph 8 projects in the sewershed and any proposed projects in the City's Wastewater System Capital Improvement Program (CIP) impacting the hydraulic capacity of the modeled system. Unlike other sewersheds in the City, the Patapsco sewershed did not have any so-called Paragraph 8 projects. This refers to Paragraph 8 of the City's Consent Decree with EPA and MDE, which required a number of design and construction projects to eliminate sanitary sewer overflows into the waters of the State. Since there were no Paragraph 8 projects in the Patapsco sewershed, the sanitary sewer system as it existed at the time of the flow monitoring program (May, 2006 to May, 2007) plus CIP projects that alter the capacity of the wastewater system represent the baseline conditions in the model. In the Patapsco sewershed, a replacement force main from the Brooklyn pumping station (SC-850) and the force main from the pumping station at the Quarantine Road Landfill that pumps leachate into Patapsco flow monitoring basin PA02 (SC-808) have been included in the baseline conditions. The pipe network of SC-850 has been added to the model, while an inflow group was added to the model to represent the flow from SC-808.

The Consent Decree also states that the future condition of the sewershed shall be modeled based on population projections and a prediction of sewer condition deterioration. The City has decided that future population estimates will be based on Year 2025 projections to provide consistency with the Consent Decree for Baltimore County. Future population estimates are based on demographic projections (population and employment forecasts) determined by the Baltimore Metropolitan Council, which consists of Baltimore City and the five surrounding Counties, including Baltimore, Howard and Anne Arundel. The hydraulic impact due to pipe deterioration has been represented in the model by increasing the amount of dry weather groundwater infiltration by 10 percent between the baseline and future condition. Additionally, any proposed system improvements beyond the Paragraph 8 projects scheduled to be completed before 2025 are to be included in the future conditions model. In the Patapsco

Sewershed, pumped flow from a future pumping station in the Hawkins Point area has been added into the future conditions simulations of the model.

The requirements stipulated in the Consent Decree and by the City of Baltimore for the Pumping Station analyses include:

1. Determining the current dry weather flows (minimum and average) and peak wet weather flows for the selected design storms contributing to each pumping station;
2. Projecting the future dry weather flows (minimum and average) and peak wet weather flows for the selected design storms contributing to each pumping station;
3. Evaluating the hydraulic capacity of all force mains and pumping stations to convey current and future dry and wet weather flows;
4. Evaluating the capacity of all major pumping station components to handle current dry and future wet weather flows including: stand-by power generator; wet well volume; pumps; motors; electrical gear (starters, VFDs, etc.); flow metering;
5. Determining peak flows for each pumping station during the selected design storms;
6. Determining the likelihood and location of overflows within a service area under high flow conditions, including pumping station service areas where the pumping station's back-up pump is out-of-service, and considering wet well capacity, off-line storage capacity, and normal in-line storage capacity.

2.0 HYDRAULIC MODEL

2.1 Hydraulic Model Network

2.1.1 General Description

As stated in the Consent Decree, the model network shall include all force mains, major gravity lines, and pumping stations and their related appurtenances. Major gravity lines are defined in the Consent Decree as:

- all gravity lines ten inches in diameter or larger;
- all eight-inch lines that convey or are necessary to accurately represent flow attributable to a service area in each of the Collection System's sewershed service areas;
- all gravity lines that convey wastewater from one pumping station service area to another pumping station service area; and
- all gravity lines that have caused or contributed, or that the City knows are likely to cause or contribute, to capacity-related overflows (utilizing the Water in Cellar [WIC] database).

The modeling software selected for the City of Baltimore Collection System Evaluation And Sewershed Plan is InfoWorks CS, by Wallingford Software, Ltd. An evaluation team for the City selected this modeling software among others available as the best suited for the City of Baltimore system. As of the date of this report, the most recent version is InfoWorks CS 10.0.3.

The horizontal coordinate system used for the hydraulic modeling is the Maryland State Plane Coordinate System (NAD83). The vertical datum used is NAVD88.

The model includes all manholes, junctions, and structures along modeled sewer lines and all control structures (e.g. weirs and pumping stations) existing in the system as required to accurately portray the wastewater collection system.

The City's wastewater geodatabase was used as the primary source of information for creating and populating the pipes and nodes network of the InfoWorks hydraulic model. WR&A utilized manhole and CCTV inspection information from project field survey efforts, along with City engineering documents from the AIRS records archive, to make numerous editing changes and enhancements to the City's wastewater GIS. A more detailed description of the development of the hydraulic model is contained in the *Model Development and Calibration Report*.

There are over 80,000 feet of sewers 10-inches and larger included in the hydraulic model of the Patapsco Sewershed. In addition, there are approximately 3500 feet of critical 8-inch sewers included in the model network. Two pumping stations are included in the model: Brooklyn, and the Patapsco Wastewater Treatment Plant (WWTP) Low

Level influent station. There are four sources of flow from Anne Arundel County, three of which are metered. The Patapsco WWTP Low Level pumping station represents the end of the model network.

2.1.2 Paragraph 8 Projects

Unlike other sewersheds in the City, the Patapsco Sewershed did not have any so-called Paragraph 8 projects. This refers to Paragraph 8 of the City's Consent Decree with EPA and MDE, which required a number of design and construction projects to eliminate or minimize sanitary sewer overflows into the waters of the State.

2.1.3 Engineered SSO Locations

There are no known engineered SSO locations in the Patapsco Sewershed.

2.2 Hydraulic Model Calibration

2.2.1 General

The hydraulic model of the Patapsco Sewershed has been calibrated for both dry and wet weather flows. A detailed description of the model calibration is contained in the *Model Development and Calibration Report*.

2.2.2 Summary of Dry Weather Calibration

Sources of data used in determining the dry weather flows included: rainfall/flow monitoring data; the City's database of water consumption records; population estimates; estimates, in linear feet, of tributary collection system to each flow monitor; and estimates of the tributary sewershed area, in acres, to each flow monitor. The flow analyses using the Sliicer.com software provide estimates of the components of the dry weather flow, specifically, the average base sanitary flow (BSF) and the groundwater infiltration (GWI) rate at each flow monitoring site. The BSF is estimated as the dry weather flow rate less the GWI estimate. In cases where there was net negative GWI, the GWI has been estimated as a percentage of the BSF based on gross flow measurements. These values were validated prior to inputting into the InfoWorks model.

The Sliicer.com analyses yields average daily dry weather flow hydrographs for each monitoring basin for both weekdays and weekends. This data was then used to develop hourly diurnal peaking factors for weekdays and weekends. This was done by first subtracting the GWI from the hourly values of the dry weather flow hydrographs and dividing by the average BSF.

The dry weather calibration began with incorporation of significant defects identified during the CCTV inspection, such as sediment depths, blockages, and other flow restrictions. Based on the type of defect identified, Manning's "n" values were changed to reflect increased pipe roughness. In addition, where CCTV or manhole inspections indicated sediment deposits, sediment depth was added to the pipe cross section. "Observed vs. Predicted" plots were generated at each flow monitoring site to see how the model compared to the observed flow meter data. Any sites that required modification to meet flow depth, volume of flow, and velocity were adjusted to have the model more closely match the flow meter results.

The hydraulic model of the Patapsco Sewershed meets the established requirements of the City of Baltimore and the Consent Decree for dry weather calibration. The shape and timing of the model hydrographs were compared to the observed and any major discrepancies were corrected. Depths and velocities were compared and the roughness factors and sediment depths, corresponding to field investigations, were adjusted in the model to more closely match the observed results. The model simulations time period for the dry weather calibration was run for one week and the predicted vs. observed volumes are totaled by InfoWorks for the time period. The hydrographs were visually inspected to ensure that peak flow rates generally matched in shape and timing. See the *Model Development and Calibration Report* for additional detail on the dry weather calibration.

2.2.3 Summary of Wet Weather Calibration

The approach to simulate wet weather flow uses the SWMM RUNOFF routines in InfoWorks CS as a synthetic storm hydrograph generator. Simulating rainfall-dependent infiltration and inflow (RDII) using SWMM RUNOFF within InfoWorks requires the specification of catchment characteristics that result in reasonable values of RDII. The parameters of the catchments to be specified are: area; R-value (percent capture); depression storage; width; slope; and overland flow routing coefficient.

The RDII volume versus rainfall depth (Q vs. i) plot for each flow monitoring site was developed using the Sliicer.com software. After reviewing the results and looking at all of the storm events, the parameters mentioned above were adjusted to have the model more accurately predict the flow meter responses.

To assess the validity of the model, a series of statistical comparison plots were produced as outlined in BaSES. Sliicer.com produces a regression line and a regression equation to represent the best fit linear function relating RDII volume to total precipitation depth. On the statistical comparison plots, a regression line with an R^2 value equal to 1.00 indicates a perfect fit between the modeled and observed peak flows and volumes. Lower R^2 values mean less agreement between observed vs. simulated flow volumes. If the intercept of the regression line is close to zero, then the modeled storm event volumes and peak flow rates are not biased (i.e., consistently over-predicting or under-predicting) with respect to the observed volumes and peak flow rates. When using winter and summer storms to develop a median "R" value in the hydraulic model, regression lines tend to vary from the ideal parameters. The summer storms, which are usually over-

Predicted when using the median R-value, have less RDII per rain depth than the winter storms, which are generally under-predicted using the median R-value in the model. This skews the graphs away from the ideal situation of a “perfect” fit. The high intensity design storms to be used in the capacity analysis are more typical of summer type storms than winter storms. With the Patapsco model calibrated using all storms in the development of capture coefficients, this provides a somewhat conservative capacity estimate, while not over-designing alternatives as compared to a model that extremely over-predicts the summer storms to meet the winter storm runoff volumes.

To conclude the wet weather calibration, the observed vs. predicted graphs generated by InfoWorks were reviewed to assess the shape and timing of the hydrographs, and adjusted if necessary to have predicted results approach observed results. For more detail on the wet weather calibration, see the *Model Development and Calibration Report.*

See Figure 2.2.3A for a map depicting the capture coefficients or “R” values for each flow meter basin, and Figure 2.2.3B for a map depicting average daily base infiltration normalized to gallons per inch-diameter-mile for each flow meter basin.

3.0 BASELINE ANALYSIS AND CAPACITY ASSESSMENT

3.1 General

Baseline conditions were defined by the City to be the conditions in effect after the completion of Paragraph 8 projects in the sewershed and any proposed projects in the City's Wastewater System Capital Improvement Program (CIP) impacting the hydraulic capacity of the modeled system. Unlike other sewersheds in the City, the Patapsco sewershed did not have any so-called Paragraph 8 projects. This refers to Paragraph 8 of the City's Consent Decree with EPA and MDE, which required a number of design and construction projects to eliminate sanitary sewer overflows into the waters of the State. Since there were no Paragraph 8 projects in the Patapsco sewershed, the sanitary sewer system as it existed at the time of the flow monitoring program (May, 2006 to May, 2007) plus CIP projects that alter the capacity of the wastewater system represent the baseline conditions in the model.

The calibrated hydraulic model has been run for both dry and wet weather flows to identify areas of the Patapsco collection system that lack adequate capacity to pass the predicted flows from the various storm events. The wet weather storm events that have been modeled include the three-month storm having a duration equal to the time of concentration for the sewershed, which was calculated to be 4 hours, and the 1, 2, 5, 10, 15 and 20-year, 24 hour storms. Maps showing the results of the return period analysis and resulting hydraulic flow restrictions are included at the end of this report.

3.2 Dry Weather Capacity Assessment

An assessment of the baseline conditions for dry weather capacity was conducted. There are no overflows in the system during dry weather. There are only two pipe segments that surcharge during peak dry weather flows. These locations are shown on Figure 3.2, which displays the percent full for modeled sewers as well as sewers experiencing surcharge during peak dry weather flow. One of the sewer segments that surcharge is S33O1_025G1, a 10-inch sewer from Seagull Avenue towards Reedbird Avenue. This sewer has a very flat slope compared to upstream sewers, and therefore has reduced capacity. Further, the sewers in this area of Cherry Hill were found to have areas of high water that prohibited CCTV inspection unless heavy cleaning was performed. After heavy cleaning, this sewer was still found to have several areas of high water and sags in the pipe that further reduce its capacity. See Section 3.3.6 of this report for additional discussion of the maintenance problems in the Reedbird Avenue area of Cherry Hill. The other sewer segment predicted to surcharge during peak dry weather flows is S55A2_002G1, a 24-inch sewer in Asiatic Avenue that discharges into the Patapsco Interceptor just upstream of the Patapsco Wastewater Treatment Plant (WWTP). This sewer has a flat slope of 0.12% and could not be inspected by CCTV due to high water conditions. As this sewer is approximately 400 feet upstream of its confluence with the

54-inch interceptor just outside of the Patapsco WWTP, backwater from the wetwell of the influent pumping station is likely affecting the water level in this sewer.

Sewers that are 75 percent full or greater during dry weather baseline flows are also highlighted on Figure 3.2. A pipe that is 75 percent full during dry weather is unlikely to have adequate capacity for either future growth or wet weather flows. Five sewer segments are between 75 and 100 percent full. These include S33O1_005G1, a 21-inch sewer in Reedbird Avenue, S33O1_019G1, also a 21-inch sewer in Reedbird Avenue immediately upstream of S33O1_005G1, and S35M1_004G1, a 12-inch sewer in Reedbird Avenue at Potee Street. All three of these sewers are in the Reedbird Avenue area of Cherry Hill where high water was experienced during the CCTV inspection program. See Section 3.3.6 of this report for additional discussion of the maintenance problems in this area of the system. S39E2_008G1, a short segment of 15-inch sewer in 5th Street near Hague Avenue, near the Anne Arundel County/Baltimore City line, is also more than 75% full. This manhole is where the flow from Anne Arundel County subsewershed BPA01 enters the City system. In addition, S55A2_017G2, a curved section of 54-inch box sewer just outside of the Patapsco WWTP and likely affected by the wet well level in the influent pumping station, is also greater than 75 percent full during peak dry weather flow.

3.3 Wet Weather Capacity Assessment

3.3.1 Storm Events

As stated previously, there are seven design storms to be analyzed. These storms include a three-month storm having a duration equal to the time of concentration for the sewershed, which was calculated to be 4 hours, and the 1, 2, 5, 10, 15 and 20-year, 24 hour duration storms. The storm distribution chosen for analysis is the NOAA Atlas 14/NRCS distribution. The precipitation depths for the seven design storms are as follows:

- 3 Month – 1.11 inches
- 1 Year – 2.67 inches
- 2 Year – 3.23 inches
- 5 Year – 4.15 inches
- 10 Year – 4.97 inches
- 15 Year – 5.41 inches
- 20 Year – 5.82 inches

3.3.2 Return Period Analysis

One of the requirements of the CD is to perform a Return Period Analysis (RPA) using the seven design storms. The InfoWorks model computes the level of surcharge and flooding in every sewer segment for each design storm event. The model also determines the smallest storm event that will surcharge and/or cause flooding (i.e., an overflow), along with the estimated flood or overflow volume. This is accomplished by selecting all of the simulations based on the design storms and loading them into the Grid Report results menu and selecting the RPA option in InfoWorks CS. The results of the baseline flooding RPA are presented in Figure 3.3.2, which shows the manholes in the sewershed and the return period of storms that will cause flooding or overflows at the manholes. As can been seen from the map, flooding occurs only at eighteen manholes during the 20-year design storm. There is no flooding during dry weather or during the 3 month storm event. Three manholes each flood during the 1 and 2 year storms. Five more manholes flood during the 5 year storm, while the 10 year storm causes four additional manholes to flood. The 15 year storm floods one additional manhole, and the 20 year storm event adds two more flooded manholes, bringing the total number of manholes with predicted overflows to eighteen. The large majority of manholes in the sewershed do not flood, even under the 20 year, 24 hour duration storm event, which is the most severe storm that was simulated.

3.3.3 Brooklyn Pumping Station Analysis

In 1999, the Brooklyn Pumping Station was modified and updated under Sanitary Contract #9539. These modifications included: new enclosed bar screen; motor operated sluice gates and valves in the wetwell; variable frequency drives on the lead pump motors; wet well exhaust improvements; and related lighting, electrical and instrumentation upgrades. Although these modifications improved the reliability of the pumping station, the hydraulic capacity was not altered.

The station has three horizontal, dry pit centrifugal pumps. Two pumps have 50 horsepower (hp) motors rated at 3600 gallons per minute (gpm), or 5.18 million gallons per day (mgd) at a Total Dynamic Head (TDH) of 38 feet. A third pump, which serves as a stand-by, is 75 hp, rated at 5700 gpm or 8.21 mgd at a TDH of 41 feet. The pumps are approximately 27 years old. There are gate valves with electric motor operators on the suction header, and plug valves with electric motor actuators that serve as pump check valves on the discharge. Variable frequency drives added during the 1999 upgrades allow the lead pumps to pump at variable rates that more closely match the station influent flow rate. The standby pump has a constant speed drive, which was also installed during the 1999 upgrades. Until recently, the pumping station discharged into a 24-inch cast iron force main, approximately 1700 feet in length, to a transition structure on Frankfurst Avenue. Because of the condition of the old force main, in late 2007, design for a new force main was completed under Sanitary Contract 850. Construction was completed in 2009. The new force main is ductile iron pipe, approximately 2000 feet in length, and ties into the existing transition structure on Frankfurst Avenue. The new force main is included in the hydraulic model for both baseline and future condition analyses. Although valving was installed under SC 850 to allow pumping into the old force main, that scenario was not modeled since the new force main is the primary and preferred means of receiving pumped flow from the Brooklyn Pumping Station.

The Brooklyn Pumping Station receives influent flow measured by flow meters PA10 and PA09. The discharge of the station is measured by a 24" magnetic meter, PSBRO. Based on flow records for this station over the period April 29, 2006 to October 27, 2007, the daily average flow was 2.09 mgd. Monthly average flow rates ranged from 1.91 mgd to 2.27 mgd, with the highest daily flow rate of 4.13 mgd recorded on April 16, 2007.

Based on flow metering data analyzed by Sliicer.com, the minimum dry weather flow to the pump station is 2.21 mgd and the average daily dry weather flow is 3.03 mgd. The peak flow rates for the pump station and the peak velocity in the force main are presented below in Table 3.3.3.

TABLE 3.3.3
BROOKLYN PUMPING STATION BASELINE CAPACITY ANALYSIS

Event	Peak Incoming Flow (mgd)	Peak Discharge Flow (mgd)	Peak Velocity in 24-inch FM (fps)
DWF	3.60	3.60	1.78
3 Month	5.34	6.81	3.35
1 Year	9.58	10.89	5.36
2 Year	10.61	10.89	5.36
5 Year	11.73	11.45	5.64
10 Year	13.76	14.53	7.16
15 Year	14.10	14.32	7.06
20 Year	14.39	14.31	7.05

Velocities greater than 7 feet per second are considered excessive for force mains. As shown in Table 3.3.3, the velocities slightly exceed 7 feet per second during the 10, 15 and 20 year storms; however, these conditions exist for only a short period when the stand by pump comes on during high flows. Under baseline conditions, the peak flows resulting from the 10, 15 and 20 year storms require that the backup pump be placed in service to reduce wet well levels that approach the high water level in the station; however, no overflows are predicted when all pumps are in service. When the analysis is performed with the backup pump out of service, the wet well does overflow during the 10, 15 and 20 year design storms. The volume that overflows the wetwell during these three storms is 600, 900 and 1200 gallons, respectively. These overflows are confined to the pump station building itself. No wastewater leaves the pumping station, nor is there a resulting overflow at an upstream manhole.

3.3.4 Patapsco WWTP Influent Pumping Station Analysis

The Patapsco WWTP Influent Pumping Station lifts wastewater from the so called low level system into the treatment facility. All of the flow in the Patapsco Interceptor, as measured by trunk sewer flow monitor TSPA03, as well as flow from a 24-inch sewer in Asiatic Avenue, measured by flow monitor PA01, enters the Patapsco WWTP and is pumped by the influent pumps in the Pump and Blower Building to the treatment processes. There are four identical raw water wastewater pumps in the station, one of which is in stand-by mode. Each variable speed, 100 hp pump has a rated capacity of 8600 gpm, or 12.38 mgd at a TDH of 40 feet. At lower heads, additional pumping capacity is available. There are no automatic pump controls. Pumps are manually started as needed based on wet well levels. One pump serves as a lead pump, with lag pump 1 started when the wet well level rises 10-inches above the lead pump set point, and lag pump 2 starting at 20-inches above the lead pump set point. The fourth pump is not routinely used and is kept in stand-by mode in case of a malfunction of one of the lead/lag pumps or for extreme wet weather events.

Based on flow records over the three year period of 2006 to 2008, the pumping station had a Daily Average Flow of just less than 7 mgd (6.954), with a low monthly average of 4.5 mgd and a high monthly average of 9.8 mgd. Normally, only one pump is in operation at the station unless high flow warrants bringing on additional units.

Based on flow metering data analyzed by Sliicer.com, the minimum dry weather flow to the pump station is 6.35 mgd and the average daily dry weather flow is 8.21 mgd. The peak flow rates for the pump station and the peak velocity in the force main are presented below in Table 3.3.4.

TABLE 3.3.4
PATAPSCO INFLUENT PUMPING STATION
BASELINE CAPACITY ANALYSIS

Event	Peak Incoming Flow (MGD)	Peak Discharge Flow (MGD)	Peak Velocity in 36-inch FM (fps)
DWF	9.60	9.62	2.11
3 Month	18.75	20.08	4.92
1 Year	37.81	38.24	9.38
2 Year	38.55	38.54	9.46
5 Year	51.86	52.89	12.98
10 Year	52.53	53.22	13.06
15 Year	60.65	63.02	15.46
20 Year	61.29	63.06	15.47

As shown in Table 3.3.4, the velocity in the Patapsco WWTP Influent Pumping Station Force Main is well above the velocity threshold of 7 feet per second for all storms except the 3-month storm. In the model network, the pumping station pumps directly into a 36-inch force main, and the velocities shown in Table 3.3.4 reflect this, resulting in the high velocities shown. In reality, the pumps discharge into a common header that has valving that can direct flow to a 24-inch force main, or to two 30-inch force mains, before entering the 36-inch force main. Flow can also be diverted into the influent channel carrying the Southwest Diversion to the Fine Screens. Given these options for directing the flow from the pumping station, it is not likely that all of the station's discharge would be pumped into the 36-inch force main during wet weather events. Therefore, the velocities stated in Table 3.3.4 are overstated.

Under baseline conditions, the peak flows resulting from the 15 and 20 year storms require that the backup pump be placed in service to reduce wet well levels that approach the high water level in the station; however, no overflows are predicted when all four pumps are in service. When the analysis is performed with the backup pump out of service, there are also no overflows. During the 15 and 20 year storms, the levels in the wet well exceed the high water level alarm point, but an overflow does not occur.

3.3.5 Predicted SSO Overflows

Under dry weather conditions, there are no overflows predicted in the Patapsco sewershed. In addition, the 3 month storm event does not cause any overflows. Sanitary sewer overflows (SSOs) begin to occur with the one year storm, with overflows at manholes S49U1_004MH, S49U1_008MH, and S51W1_007MH, all in flow monitoring basin PA01, as shown in Figure 3.3.2. This map depicts the smallest storm event which causes a manhole to overflow. A summary of the baseline manhole SSO volumes, based on the design storm return periods that cause flooding, is shown in Table 3.3.5.

TABLE 3.3.5
BASELINE MANHOLE SSO VOLUMES

Manhole ID	3 month (MG)	1 Year (MG)	2 Year (MG)	5 Year (MG)	10 Year (MG)	15 Year (MG)	20 Year (MG)
S49U1_004MH		0.0219	0.0633	0.1084	0.1418	0.1582	0.1731
S49U1_008MH		0.0014	0.0414	0.1462	0.2452	0.3006	0.3530
S51W1_007MH		0.0222	0.0664	0.1444	0.2173	0.2591	0.2991
S35M1_007MH			0.0019	0.0372	0.1300	0.2048	0.2811
S43M2_002MH			0.0049	0.1640	0.2955	0.3471	0.3884
S51S1_003MH			0.0042	0.0424	0.0781	0.1050	0.1406
S39E2_008MH				0.0054	0.0494	0.0824	0.1167
S45K2_014MH				0.0226	0.0429	0.0514	0.0587
S47U1_001MH				0.0091	0.0319	0.0475	0.0632
S51S1_002MH				0.0005	0.0080	0.0131	0.0170
S51S1_004MH				0.0029	0.0082	0.0109	0.0133
S43M2_001MH					0.0795	0.1554	0.2374
S45I2_017MH					0.0104	0.0150	0.0185
S45I2_035MH					0.0011	0.0084	0.0175
S51U1_004MH					0.0027	0.0078	0.0124
S41U1_006MH						0.0035	0.0482
S33O1_018MH							0.0003
S51U1_003MH							0.0024
TOTALS	0	0.0455	0.1821	0.6831	1.3420	1.7702	2.2409

This table shows each manhole ID and the SSO volume, in million gallons, for each design storm that is predicted to cause an overflow at that manhole. The total volume of overflows from all manholes from each design storm is also totalized. There are no engineered overflows in the Patapsco sewershed. As noted in the table, manhole S49U1_008MH is one of the first three manholes to flood during the 1 year storm, and has the largest volume of flooding during the 20 year storm. A total of 2.2409 MG overflows the system during the 20 year storm event.

3.3.6 Baseline Hydraulic Flow Restriction

One of the requirements of the Consent Decree is to identify and map all components of the wastewater collection system that restricts the flow of wastewater through the collection system that cause or contribute, or are likely to cause or contribute to overflows from the collection system. InfoWorks CS has the ability to determine system components that restrict flow, thus potentially leading to an overflow. This analysis is performed by the software, by comparing the slope of each sewer segment to the slope of the hydraulic grade line at peak flow. A surcharged sewer with a pipe slope that is flatter than the slope of the hydraulic grade line indicates that the sewer is restricting flow, i.e., there is a capacity bottleneck or restriction. If the pipe slope is steeper than the slope of the hydraulic grade line, then the surcharge is not necessarily caused by a capacity limitation in that pipe. This indicates that the sewer segment is in a backwater condition caused by a downstream control structure or an obstruction.

Figure 3.3.6 depicts the results of this analysis, showing the smallest storm event that causes sewer restrictions leading to an upstream overflow. The map also shows the length of sewers with restrictions and the manholes with predicted overflows. A summary of pipe sizes and cumulative lengths of restricted sewer lengths for each design storm are shown in Table 3.3.6 below.

Table 3.3.6
BASELINE RESTRICTION LENGTH OF SEWER (FT)
BY PIPE SIZE AND STORM EVENT

Diameter	3 Month	1 Year	2 Year	5 Year	10 Year	15 Year	20 Year
< 10”	176	676	2033	3123	3596	3596	3704
10” – 19”	2717	12421	14227	17968	22623	23973	36097
20” – 29”	866	3070	3485	6717	11441	14478	15487
30” – 39”		1789	2494	5698	6121	6121	6121
> 40”		424	1558	7284	11349	16116	16131
Total Length	3759	18380	23797	40790	55130	64284	67540

Most of the pipe capacity restrictions are due to excessive inflow/infiltration into the system resulting from the wet weather events noted above. As noted in Table 3.3.6, over 80 percent of the modeled sewers have hydraulic restrictions under the 20 year storm event. Despite this relatively high percentage, very few SSO's are predicted to occur, as explained in Section 3.3.5.

In addition to the wet weather impacts, there are locations where construction defects and/or maintenance issues are either the primary or at least a contributory cause of pipe capacity restrictions. One of these areas is Reedbird Avenue and Cherryland Road. A 21-inch sewer flows southwesterly down Reedbird Avenue from Potee Street. A 27-inch sewer flows northeasterly in the abandoned roadbed from Patapsco Avenue, and a 15-inch sewer flows southeasterly down Cherryland Road. All three sewers converge at manhole S33Q1_001MH. A 33-inch sewer exits this manhole, transitions to 30-inch, and flows under the Patapsco River to the Brooklyn Pumping Station. See Figure 3.3.6 for an overview of this area of the system, and Figure 3.3.7 for a partial plan and profile of this sewer. During CCTV inspections, tons of debris were removed from S33Q1_001MH. In addition, high water conditions were noted in the 27-inch, 21-inch, 30-inch and 33-inch sewers, as well as in manhole S33Q1_001MH. Elevated water levels were noted as far downstream as manhole S37S1_006MH, approximately 2400 feet away, indicative of large amounts of debris and sediment in the 30-inch sewer crossing the Patapsco River. In fact, CCTV inspections of the 30-inch sewer from Reedbird Avenue toward the Brooklyn Pumping Station showed hard compacted sediment filling approximately 25% of the pipe depth.

3.3.7 Baseline Maximum Allowable Flows Before Overflows

One of the requirements of the Consent Decree is to identify system components that restrict flow and to quantify the maximum flows that the identified components can handle before an overflow occurs (CD Paragraph 9.F.v.a and b). With the goal of removing SSOs from the system, the main concern is whether a component causes an overflow or not, and if so, when does it occur. The system components identified that lead to SSOs and the corresponding level of service (i.e., the largest design storm that does not cause an overflow) are discussed in detail in Section 3.3.6. It should be noted that there are no engineered overflow locations in the Patapsco sewershed, nor have there been any documented overflows due to capacity restrictions. Localized overflows and basement backups documented by the City's Maintenance Work Order records have been the result of roots, grease, or other debris in small diameter collector sewers (6 or 8-inch) or in the service laterals.

4.0 FUTURE (YEAR 2025) ANALYSIS AND CAPACITY ASSESSMENT

4.1 General

The Consent Decree (CD) states that future conditions shall be based on projections for population and sewer condition deterioration for the Year 2020. The City has since decided that the future projections will be based on the Year 2025 to provide consistency with the Consent Decree for Baltimore County. Future population estimates are based on demographic projections determined by the Baltimore Metropolitan Council, which consists of Baltimore City and the five surrounding Counties, including Baltimore, Howard and Anne Arundel. A file containing future wastewater flows based on the population projections by Sewer Service Area (SSA) was provided by the Technical Program Manager. These flow projections for the SSA's were then aggregated into the larger subsewersheds corresponding to the flow metering basins. The hydraulic impact due to pipe deterioration has been represented in the model by increasing the amount of dry weather groundwater infiltration by 10 percent between the baseline and future condition. A detailed analysis for estimating future flows is discussed in the City's December 2007 Report *Current and Future Dry Weather Base Sanitary Flows*.

4.2 Dry Weather Capacity Assessment

A dry weather flow assessment was performed for the future flow condition similar to the dry weather assessment completed for the baseline flow condition. The only difference is that in the future condition, there is an additional 1.06 mgd combined base sanitary flow and infiltration produced in the sewershed due to population increases and pipe deterioration. There are two more segments of surcharged sewers under future conditions compared to the baseline conditions. The two pipes that are surcharged under both baseline and future conditions are discussed in Section 3.2. In addition, S33O1_019G1 and S39E2_008G1 surcharge under future conditions. These sewers were greater than 75% full under the baseline analysis described in Section 3.2. Figure 4.2 depicts the percent full for each pipe during peak dry weather flow under future conditions. Four sewers have future dry weather flows between 75 and 100 percent of capacity.

4.3 Wet Weather Capacity Assessment

4.3.1 Storm Events

Similar to the baseline analysis, there are seven design storms that are to be modeled for future flow conditions. These are the same design storms used in the baseline analysis. The design storms are: a three-month storm having a duration equal to the time of concentration for the sewershed (4 hours), and the 1, 2, 5, 10, 15, and 20-year, 24 hour duration storms. The storm distribution chosen for this analysis is NRCS/NOAA Atlas 14. The precipitation depths for the seven design storms are as follows:

- 3 Month – 1.11 inches
- 1 Year – 2.67 inches
- 2 Year – 3.23 inches
- 5 Year – 4.15 inches
- 10 Year – 4.97 inches
- 15 Year – 5.41 inches
- 20 Year – 5.82 inches

4.3.2 Return Period Analysis

As with the baseline conditions, a requirement of the CD is to perform a Return Period Analysis (RPA) for the future condition using the seven design storms. The InfoWorks model computes the level of surcharge and flooding in every sewer segment for each design storm event. The model also determines the smallest storm that will surcharge and cause flooding (i.e., an overflow), along with the estimated flood or overflow volume. This is accomplished by selecting all of the simulations based on the design storms and loading them into the Grid Report results menu and selecting the RPA option in InfoWorks CS. The results of the future condition RPA are presented in Figure 4.3.2. which shows the manholes in the sewershed and the return period of storms that will cause flooding or overflows at the manholes. As can been seen from the map, flooding occurs only at eighteen manholes during the 20 year storm. There is no flooding during dry weather or during the 3 month storm event. Three manholes flood during the 1 year storm, with four additional manholes flooding due to the 2 year storm. Five manholes flood during the 5 year storm, while the ten year storm causes flooding in three additional manholes. The 15 year storm causes one additional manhole to flood, while the 20 year storm floods two additional manholes, bringing the total number of manholes with predicted overflows to eighteen. This is the same number manholes that are predicted to flood under the baseline conditions. Most of the manholes in the sewershed do not flood, even under the 20 year, 24 hour duration storm event, which is the most severe storm that was simulated.

4.3.3 Brooklyn Pumping Station Analysis

There are no planned improvements to the Brooklyn Pumping Station. Therefore, the baseline conditions model and future conditions model (year 2025) for the Brooklyn Pumping Station have the same design and operating parameters. See Section 3.3.3 of this report for detailed information on the capacity of the pumping station.

Based on flow metering data analyzed by Sliicer.com, the minimum dry weather flow to the pump station is 2.44 mgd and the average daily dry weather flow is 3.32 mgd. The peak pump station flow rates and velocities in the force main for future conditions for each of the design storms are presented below in Table 4.3.3.

TABLE 4.3.3 BROOKLYN PUMPING STATION FUTURE CAPACITY ANALYSIS			
Event	Peak Incoming Flow (MGD)	Peak Discharge Flow (MGD)	Peak Velocity in 24-inch FM (fps)
DWF	3.96	3.98	1.96
3 Month	5.65	6.79	3.35
1 Year	9.58	10.89	5.36
2 Year	10.88	10.89	5.36
5 Year	13.66	14.93	7.36
10 Year	13.82	14.54	7.16
15 Year	14.18	14.33	7.06
20 Year	14.46	14.39	7.09

Velocities greater than 7 feet per second are considered excessive for force mains. As shown in Table 4.3.3 and similar to the baseline assessment, the velocities slightly exceed 7 feet per second during the 5, 10, 15 and 20 year storms; however, these conditions exist for only a short period when the stand by pump comes on during high flows. Even with the peak flows resulting from the 20 year storm, there are no overflows predicted to occur at this station with all pumps running. Under future conditions, the peak flows resulting from the 5, 10, 15 and 20 year storms require that the backup pump be placed in service to reduce wet well levels that approach the high water level in the station; however, no overflows are predicted. When the analysis is performed with the backup pump out of service, the wet well does overflow during the 10, 15 and 20 year design storms. During the 5 year storm, the high level alarm of the wetwell is activated, but it does not overflow. The volume that overflows the wetwell during these three storms is 700, 1000 and 1300 gallons, respectively. These overflows are confined to the pump station building itself. No wastewater leaves the pumping station, nor is there a resulting overflow at an upstream manhole.

4.3.4 Patapsco WWTP Influent Pumping Station Analysis

There are no planned improvements to the Patapsco WWTP Influent Pumping Station. Therefore, the baseline conditions model and future conditions model (year 2025) for the Patapsco WWTP Influent Pumping Station has the same design and operating parameters. See Section 3.3.4 of this report for detailed information on the capacity of the pumping station.

Based on flow metering data analyzed by Sliicer.com, the minimum dry weather flow to the pump station is 7.0 mgd and the average daily dry weather flow is 9.27 mgd. The peak pump station flow rates and velocities in the force main for future conditions for each of the design storms are presented below in Table 4.3.4.

TABLE 4.3.4 PATAPSCO WWTP INFLUENT PUMPING STATION FUTURE CAPACITY ANALYSIS			
Event	Peak Incoming Flow (MGD)	Peak Discharge Flow (MGD)	Peak Velocity in 36-inch FM (fps)
DWF	10.90	10.94	2.40
3 Month	20.05	20.08	4.93
1 Year	37.87	38.23	9.38
2 Year	39.19	39.18	9.62
5 Year	51.93	52.90	12.98
10 Year	53.82	53.80	13.20
15 Year	61.28	63.22	15.51
20 Year	61.88	63.11	15.49

As shown in Table 4.3.4, the velocity in the Patapsco WWTP Influent Pumping Station Force Main is well above the velocity threshold of 7 feet per second for all storms except the 3-month storm. In the model network, the pumping station pumps directly into a 36-inch force main, and the velocities shown in Table 4.3.4 reflect this, resulting in the high velocities shown. In reality, the pumps discharge into a common header that has valving that can direct flow to a 24-inch force main, or to two 30-inch force mains, before entering the 36-inch force main. Flow can also be diverted into the influent channel carrying the Southwest Diversion to the Fine Screens. Given these options for directing the flow from the pumping station, it is not likely that all of the station's discharge would be pumped into the 36-inch force main during wet weather events. Therefore, the velocities stated in Table 4.3.4 are overstated.

Under future conditions, the peak flows resulting from the 15 and 20 year storms require that the backup pump be placed in service to reduce wet well levels that approach the high water level in the station; however, no overflows are predicted. When the analysis is performed with the backup pump out of service, the only predicted overflow is during the 20 year storm. The volume that overflows the wetwell during the 20 year storm is 1800 gallons. This overflow is confined to the pump station building itself. No wastewater leaves the pumping station, nor is there a resulting overflow at an upstream manhole.

4.3.5 Predicted SSO Overflows

Under dry weather conditions, there are no overflows predicted in the Patapsco sewershed. In addition, the 3 month storm event does not cause any overflows. Sanitary sewer overflows (SSOs) begin to occur with the one year storm, with overflows at manholes S49U1_004MH, S49U1_008MH, and S51W1-007MH, all in flow metering basin PA01, as shown in Figure 4.3.2. This figure depicts the smallest storm event which causes a manhole to flood or overflow. A summary of the future manhole SSO volumes, based on the design storm return periods that cause flooding, is shown in Table 4.3.5. This table shows each manhole ID and the SSO volume, in million gallons, for each design storm that is predicted to cause an overflow at that manhole. The total volume of overflows from all manholes from each design storm is also totalized. There are no engineered overflows in the Patapsco sewershed.

TABLE 4.3.5
FUTURE MANHOLES SSO VOLUMES

Manhole ID	3 month (MG)	1 Year (MG)	2 Year (MG)	5 Year (MG)	10 Year (MG)	15 Year (MG)	20 Year (MG)
S49U1_004MH		0.0243	0.0697	0.1110	0.1446	0.1612	0.1764
S49U1_008MH		0.0022	0.0444	0.1501	0.2506	0.3066	0.3584
S51W1_007MH		0.0379	0.0881	0.1667	0.2417	0.2842	0.3234
S35M1_007MH			0.0034	0.0445	0.1501	0.2305	0.3096
S43M2_002MH			0.0105	0.1826	0.3142	0.3653	0.4047
S45K2_014MH			0.0001	0.0229	0.0434	0.0518	0.0591
S51S1_003MH			0.0054	0.0446	0.0869	0.1272	0.1618
S39E2_008MH				0.0104	0.0599	0.0954	0.1315
S43M2_001MH				0.0012	0.0898	0.1692	0.2542
S47U1_001MH				0.0099	0.0329	0.0487	0.0650
S51S1_002MH				0.0006	0.0082	0.0133	0.0172
S51S1_004MH				0.0032	0.0076	0.0100	0.0137
S45I2_017MH					0.0105	0.0150	0.0185
S45I2_035MH					0.0011	0.0085	0.0176
S51U1_004MH					0.0027	0.0079	0.0126
S41U1_006MH						0.0105	0.0969
S33O1_018MH							0.0014
S39U1_008MH							0.0002
S51A2_009MH							0.0005
S51U1_003MH							0.0025
TOTALS	0	0.0644	0.2216	0.7477	1.4442	1.9053	2.4252

As noted in the table, manhole S43M2_002MH, which starts to flood during the 2 year storm, has the largest volume of flooding during the 20 year storm. A total of 2.4252 MG overflows the system during the 20 year storm. Only two more manholes flood during the future conditions than for the baseline conditions, producing 184,300 gallons more in SSO volume.

4.3.6 Hydraulic Flow Restriction

Another requirement of the Consent Decree is to identify and map all components of the wastewater collection system that restrict the flow of wastewater through the collection system that cause or contribute, or are likely to cause or contribute, to overflows from the collection system. InfoWorks CS has the capability to determine which system components restrict flow, thus potentially leading to an overflow.

Map 4.3.6 depicts the results of this analysis for the future condition, showing the smallest storm event that causes sewer restrictions leading to an upstream overflow. The map also shows the length of sewers with restrictions and the manholes with predicted overflows. A summary of pipe sizes and cumulative lengths of restricted sewer lengths for each design storm are shown in Table 4.3.6.

Table 4.3.6
FUTURE RESTRICTION LENGTH OF SEWER (FT)
BY PIPE SIZE AND STORM EVENT

Diameter	3 Month	1 Year	2 Year	5 Year	10 Year	15 Year	20 Year
< 10”	342	975	2033	3123	3596	3596	3738
10” – 19”	2772	12857	14280	19072	23033	25019	26765
20” – 29”	866	3070	4035	8043	11827	14918	16245
30” – 39”		2149	2880	5980	6121	6121	6121
> 40”		424	3113	7774	15222	16131	16131
Total Length	3980	19475	26341	43992	59799	65785	69000

There is only a small increase in the footage of restricted sewers under future conditions compared to baseline conditions, with 1,460 feet of additional restrictions resulting from the 20 year storm. This small increase reflects the small growth in population forecasts for the Patapsco sewershed. In addition, the same construction defects and maintenance issues that may contribute to capacity restrictions in the baseline model are also present for the future conditions. For additional discussion of these issues, see Section 3.3.6 of this report. Despite restrictions in over 80 per cent of the sewers in the sewershed, very few manholes experience flooding.

4.3.7 Future Maximum Allowable Flows Before Overflows

Another requirement of the Consent Decree is to identify system components that restrict flow and to quantify the maximum flows that the identified components can handle before an overflow occurs (CD Paragraph 9.F.v.a and b). With the goal of removing SSOs from the system, the main concern is whether a component causes an overflow or not, and if so, when does it occur. The system components identified that lead to SSOs and the corresponding level of service (i.e., the largest design storm that does not cause an overflow) are discussed in detail in Section 4.3.6. It should be noted that there are no engineered overflow locations in the Patapsco sewershed. The Future Conditions Model will be used to develop alternatives to eliminate all SSOs caused by the identified restrictions.

FIGURES

PATAPSCO SEWERSHED

LEGEND

SEWERSHED BOUNDARY	GRAVITY INTERCEPTOR
PUMPING STATION	SOUTHWEST DIVERSION PRESSURE SEWER (INCLUDED IN GWYNN'S FALLS SEWERSHED STUDY)
WASTEWATER TREATMENT PLANT	FORCE MAIN

WR&A

CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING

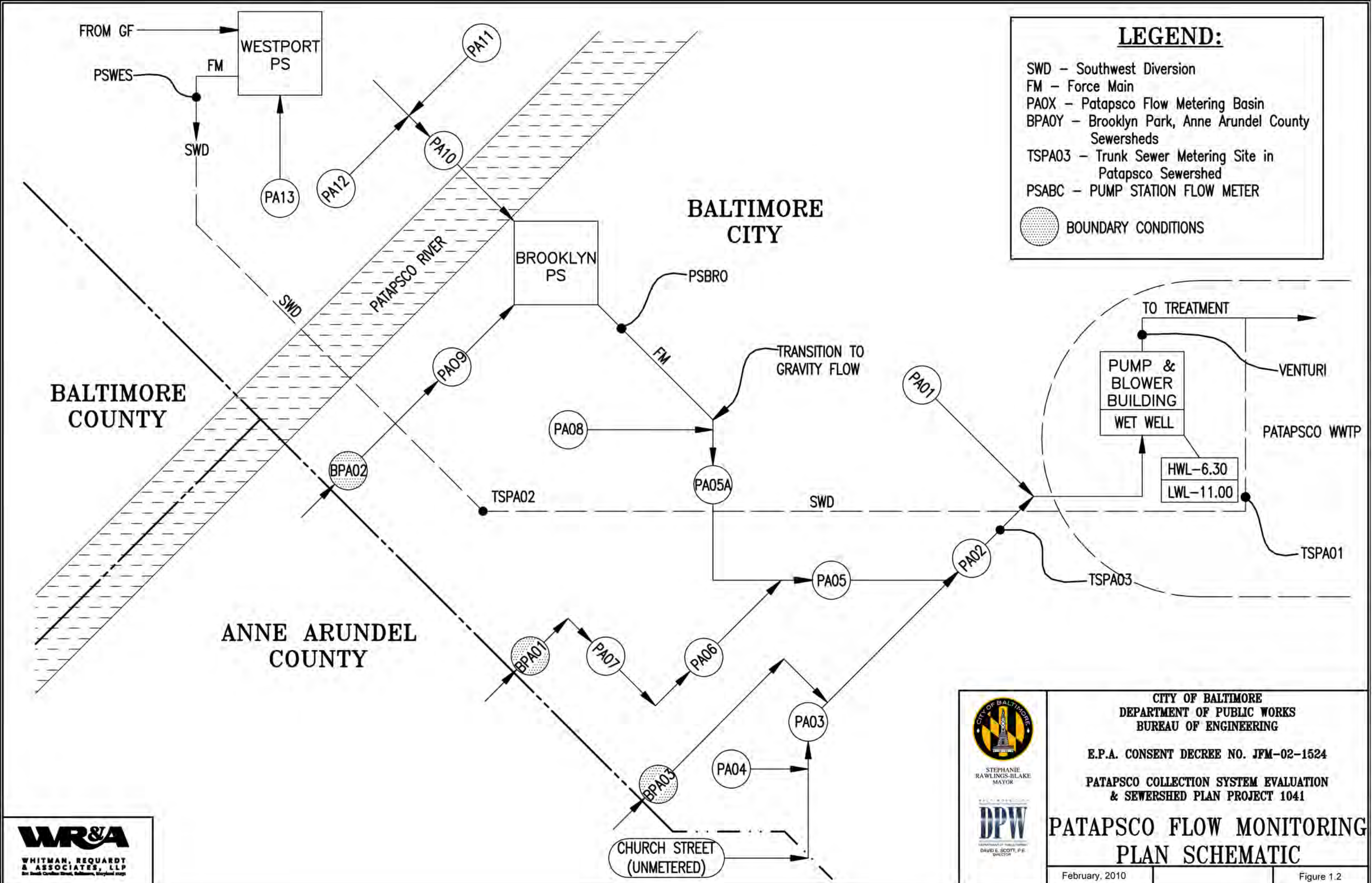
E.P.A. CONSENT DECREE NO. JFM-02-1524

PATAPSCO COLLECTION SYSTEM EVALUATION & SEWERSHED PLAN PROJECT 1041

PATAPSCO SEWERSHED AND SURROUNDING AREA

DATE: February, 2010

FIGURE: 1.1



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MAYOR

DPW
DAVID E. SCOTT, P.E.
DIRECTOR

E.P.A. CONSENT DECREE NO. JFM-02-1524

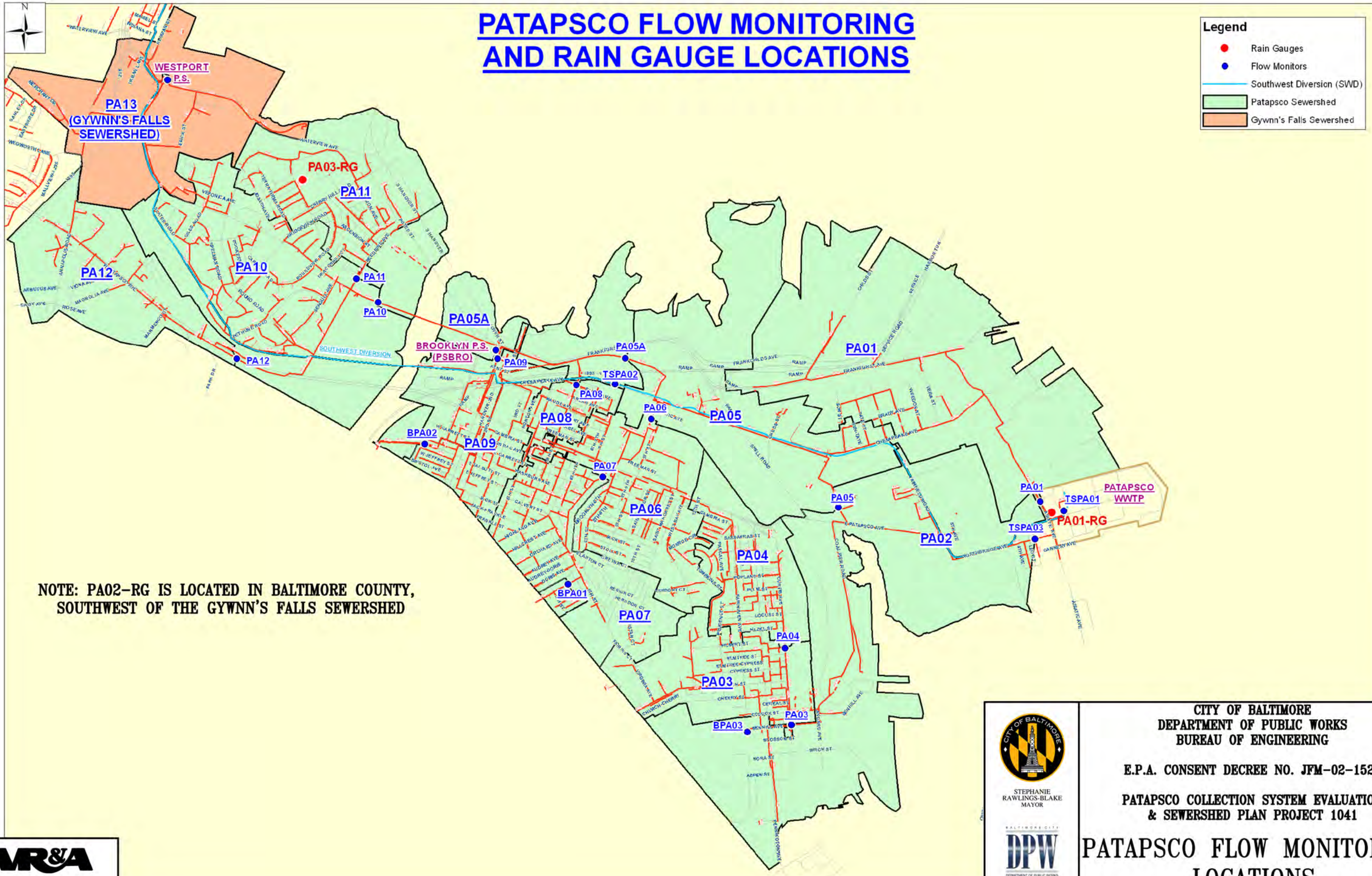
PATAPSCO COLLECTION SYSTEM EVALUATION & SEWERSHED PLAN PROJECT 1041

PATAPSCO FLOW MONITORING PLAN SCHEMATIC

February, 2010

Figure 1.2

PATAPSCO FLOW MONITORING AND RAIN GAUGE LOCATIONS



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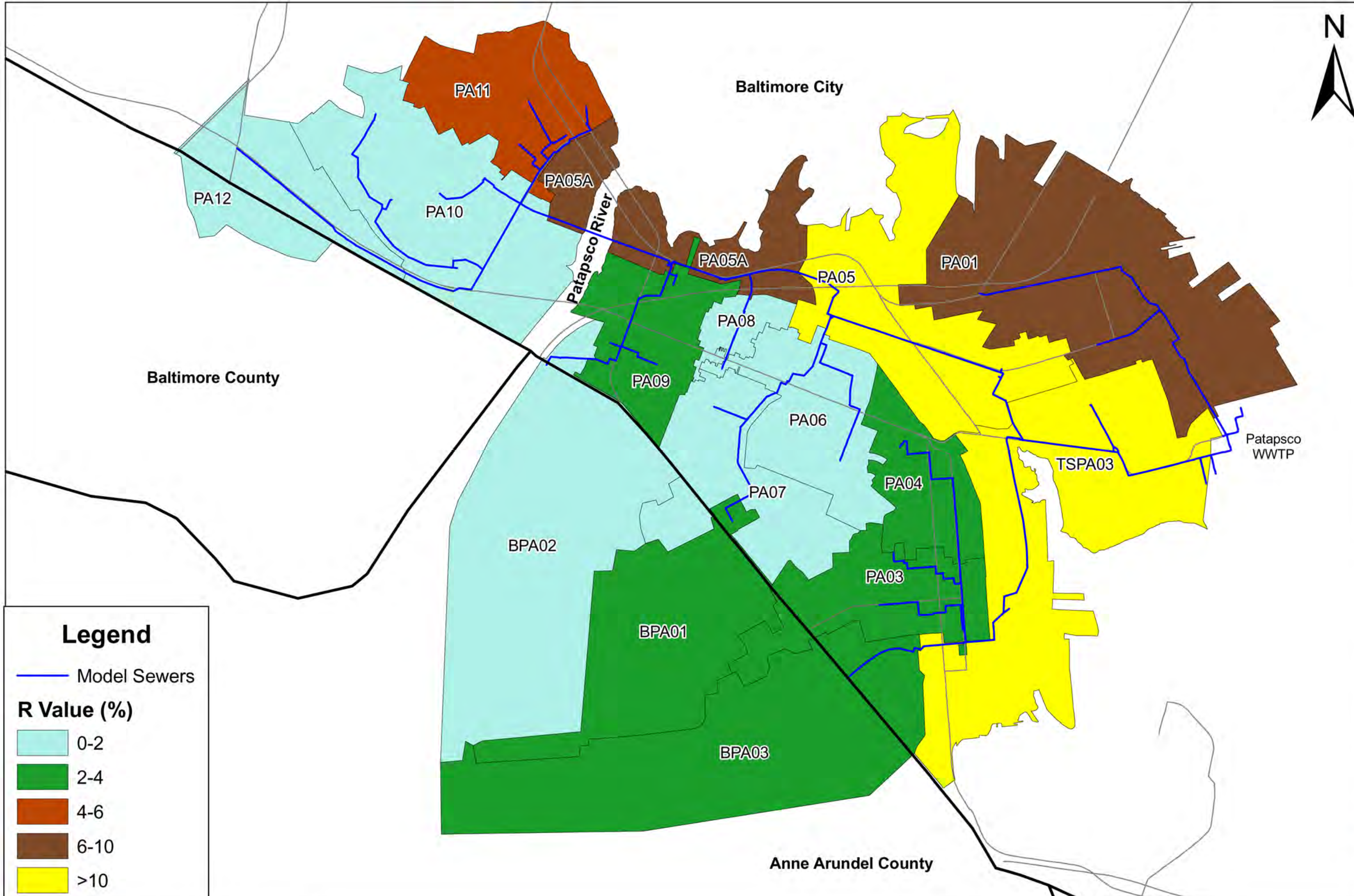
PATAPSCO COLLECTION SYSTEM EVALUATION & SEWERSHED PLAN PROJECT 1041

PATAPSCO FLOW MONITORING LOCATIONS

February, 2010			Figure 1.3



1 inch equals 2,000 feet

Capture Coefficients (R Values)

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FIGURE 2.2.3A

n:\70721-000\GIS\mapfiles\capture_coefficients.mxd

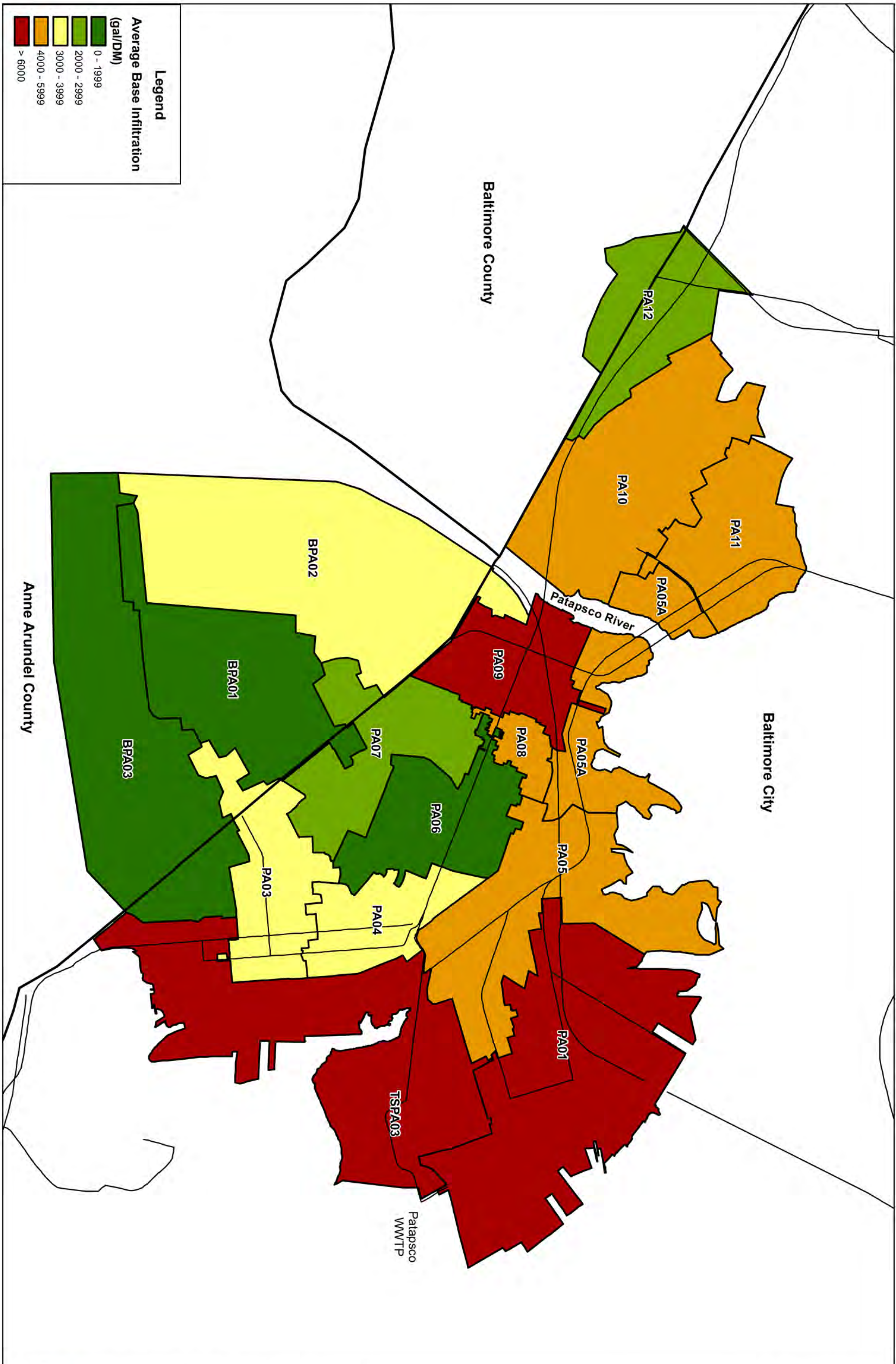

FIGURE 2.2.3B

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STEPHANIE RAWLINGS-BLAKE MAYOR

Average Base Infiltration

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1 inch equals 2,000 feet

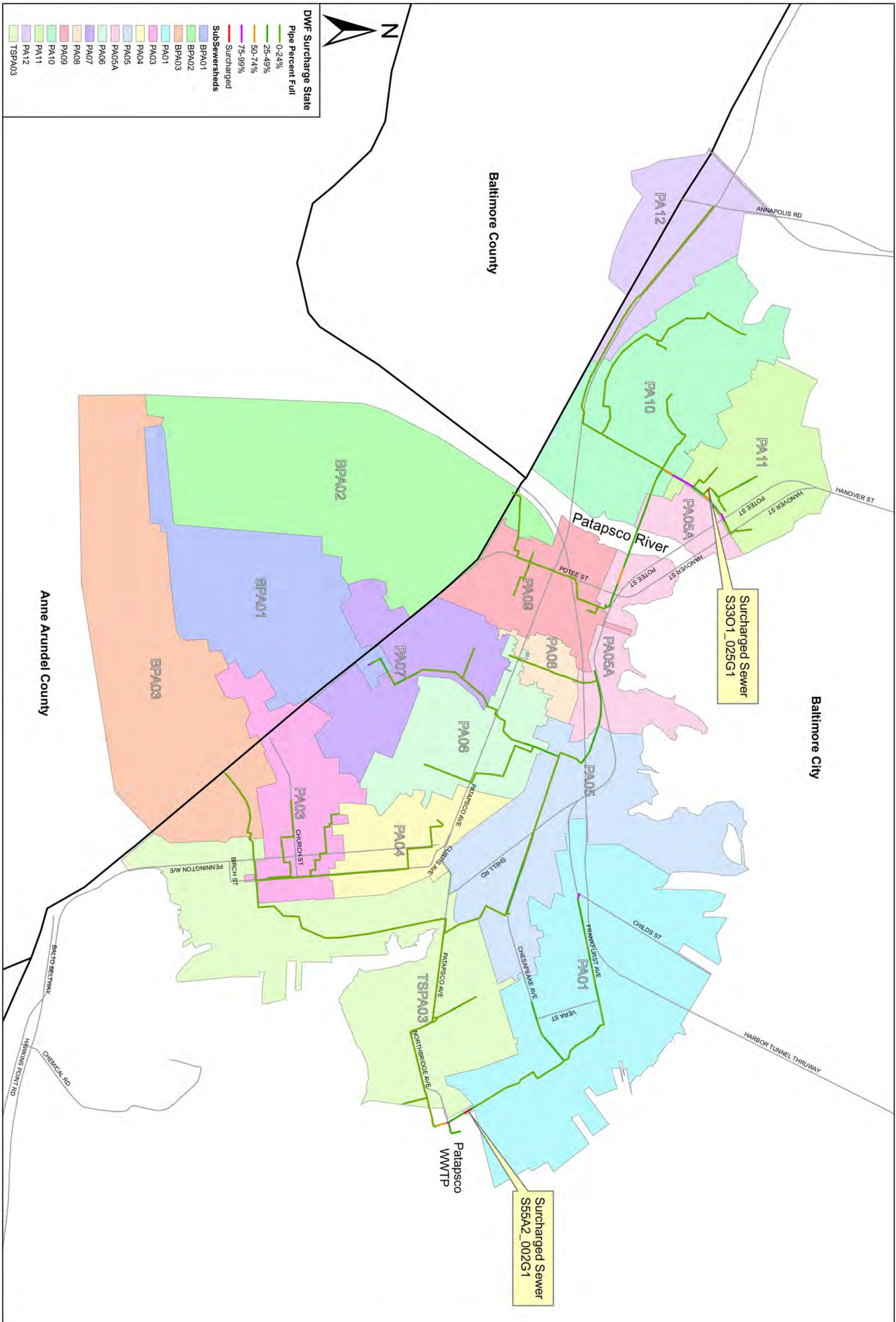

FIGURE 3.2

STEPHANIE RAWLINGS-BLAKE
MAYOR

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Dry Weather Event Baseline Conditions Capacity Analysis

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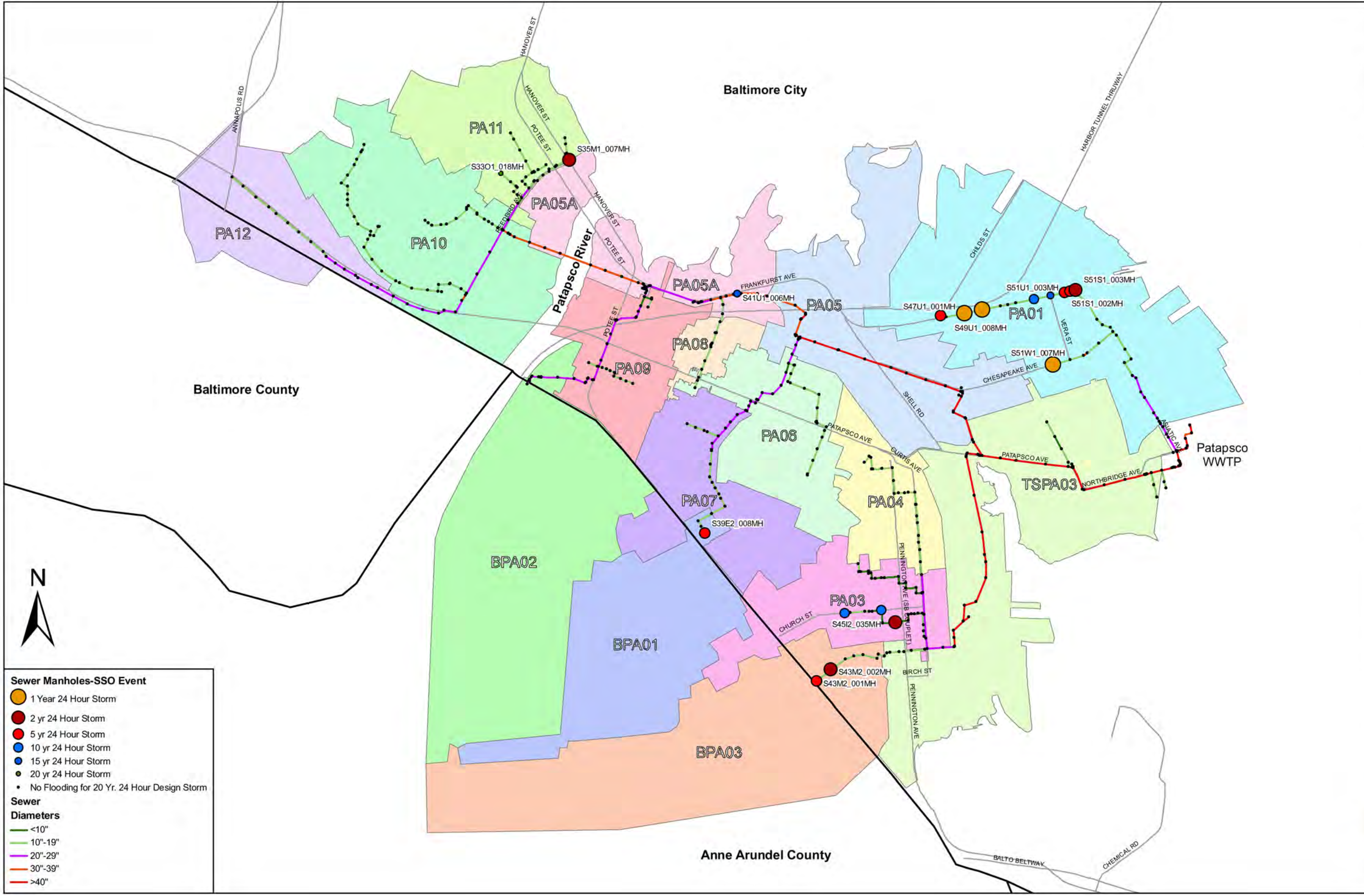
1 inch equals 2,000 feet



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1 inch equals 2,000 feet

Wet Weather Event Baseline Conditions Return Period Analysis

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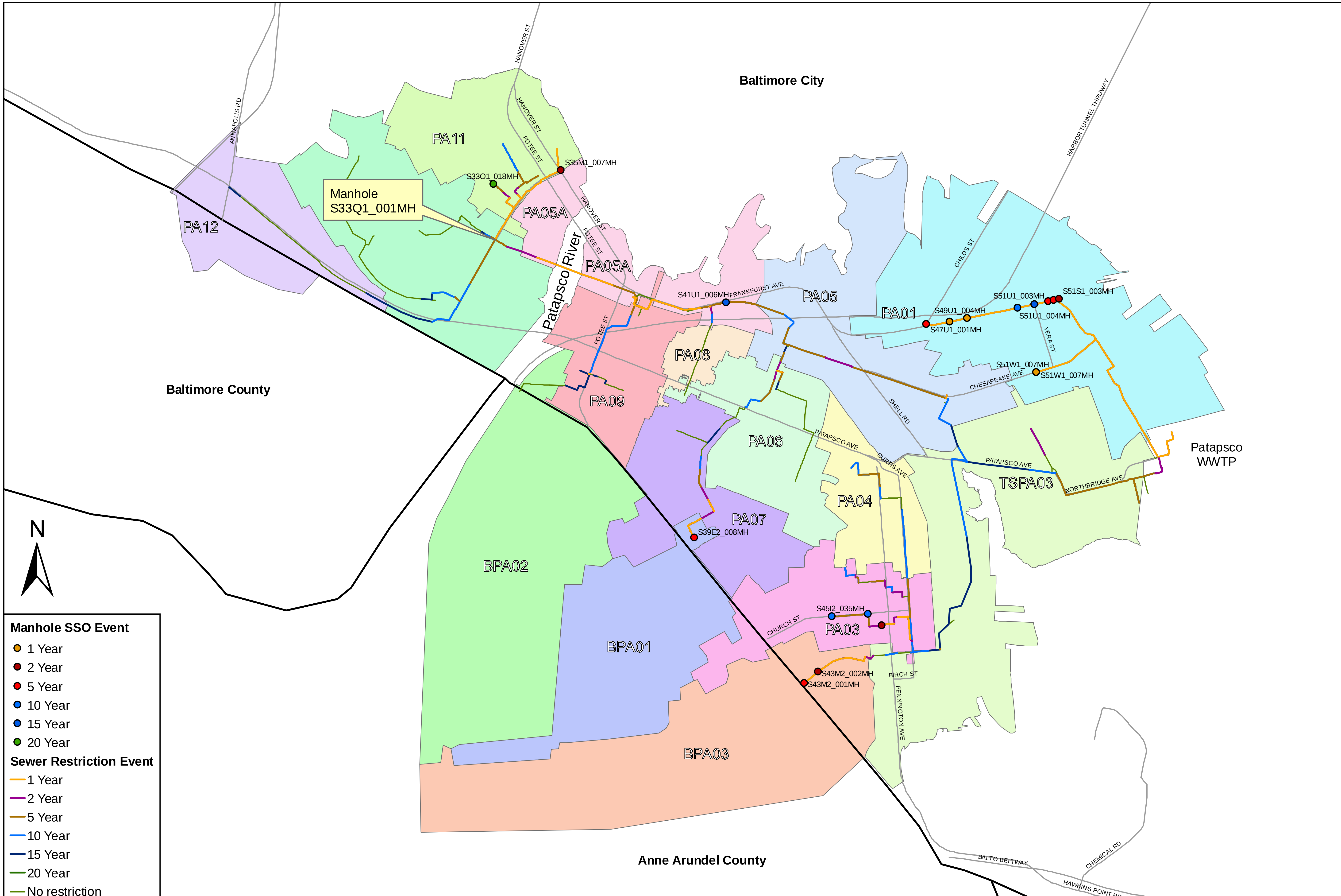
CITY OF BALTIMORE
STEPHANIE RAWLINGS-BLAKE MAYOR

FIGURE 3.3.2



February 2010
1 inch equals 2,000 feet

Wet Weather Event Baseline Conditions Hydraulic Restrictions Analysis

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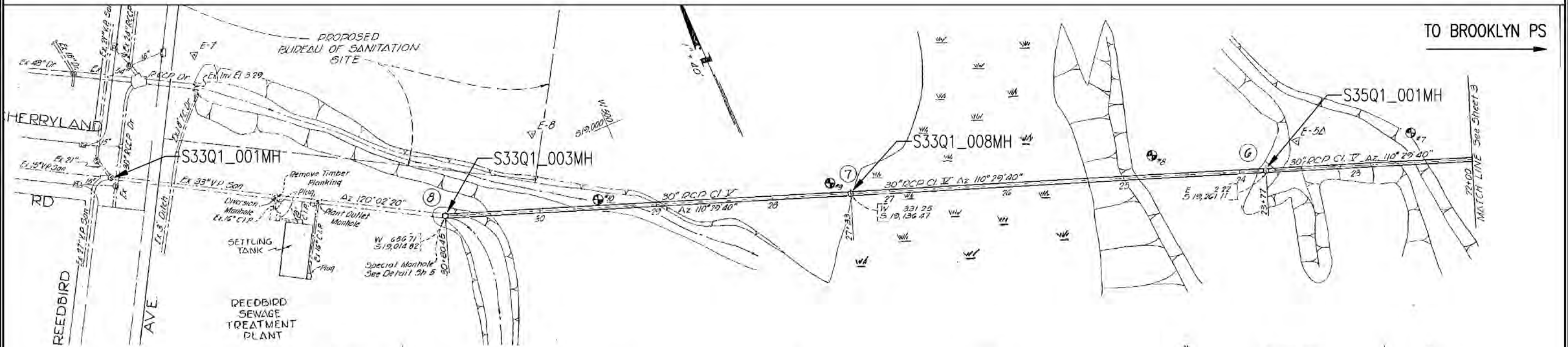
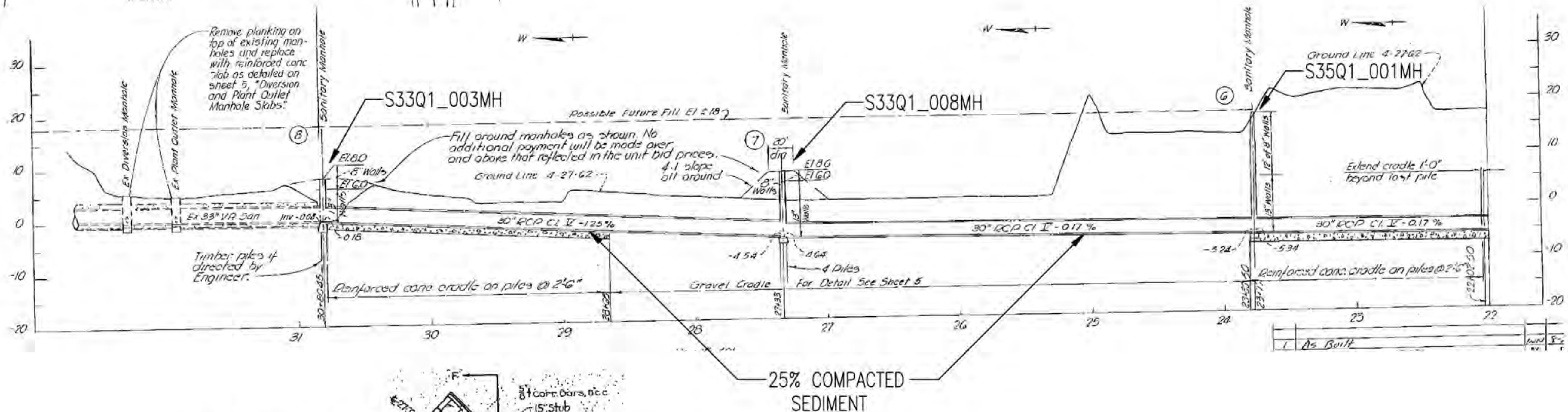
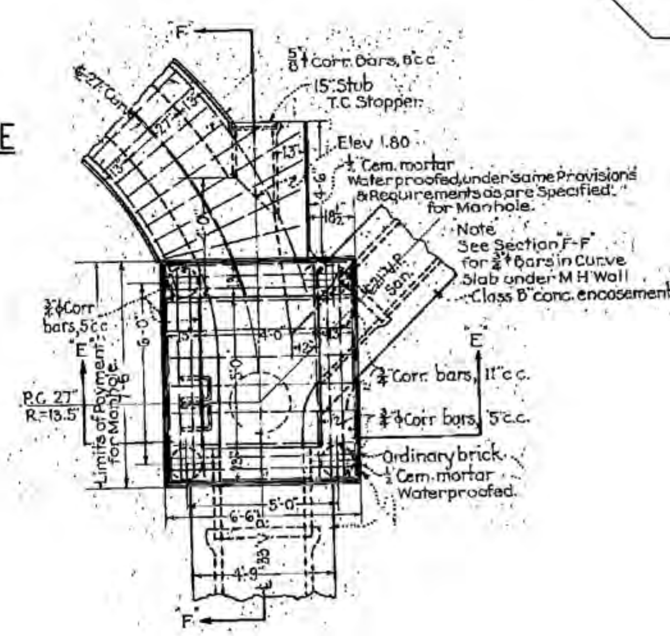
FIGURE 3.3.6







PLAN OF MANHOLE S33Q1_001MH

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PATAPSCO COLLECTION SYSTEM EVALUATION & SEWERSHED PLAN PROJECT 1041

30" GRAVITY SEWER

REEDBIRD AVENUE TO BROOKLYN PS

FIGURE: 3.3.7

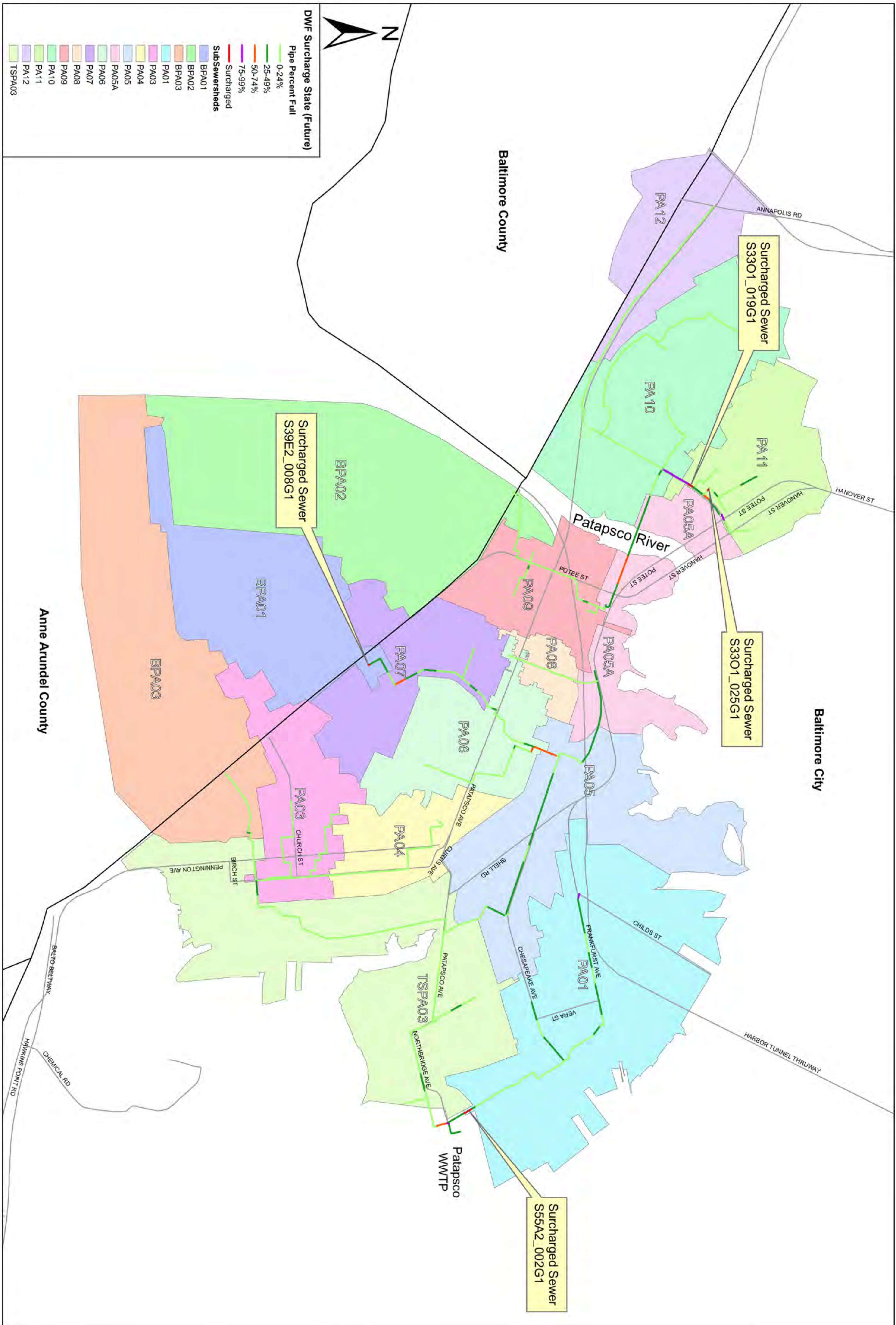

FIGURE 4.2

STEPHANIE RAWLINGS-BLAKE
MAYOR

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Dry Weather Event Future Conditions Capacity Analysis

WR&A

February 2010

1 inch equals 2,000 feet

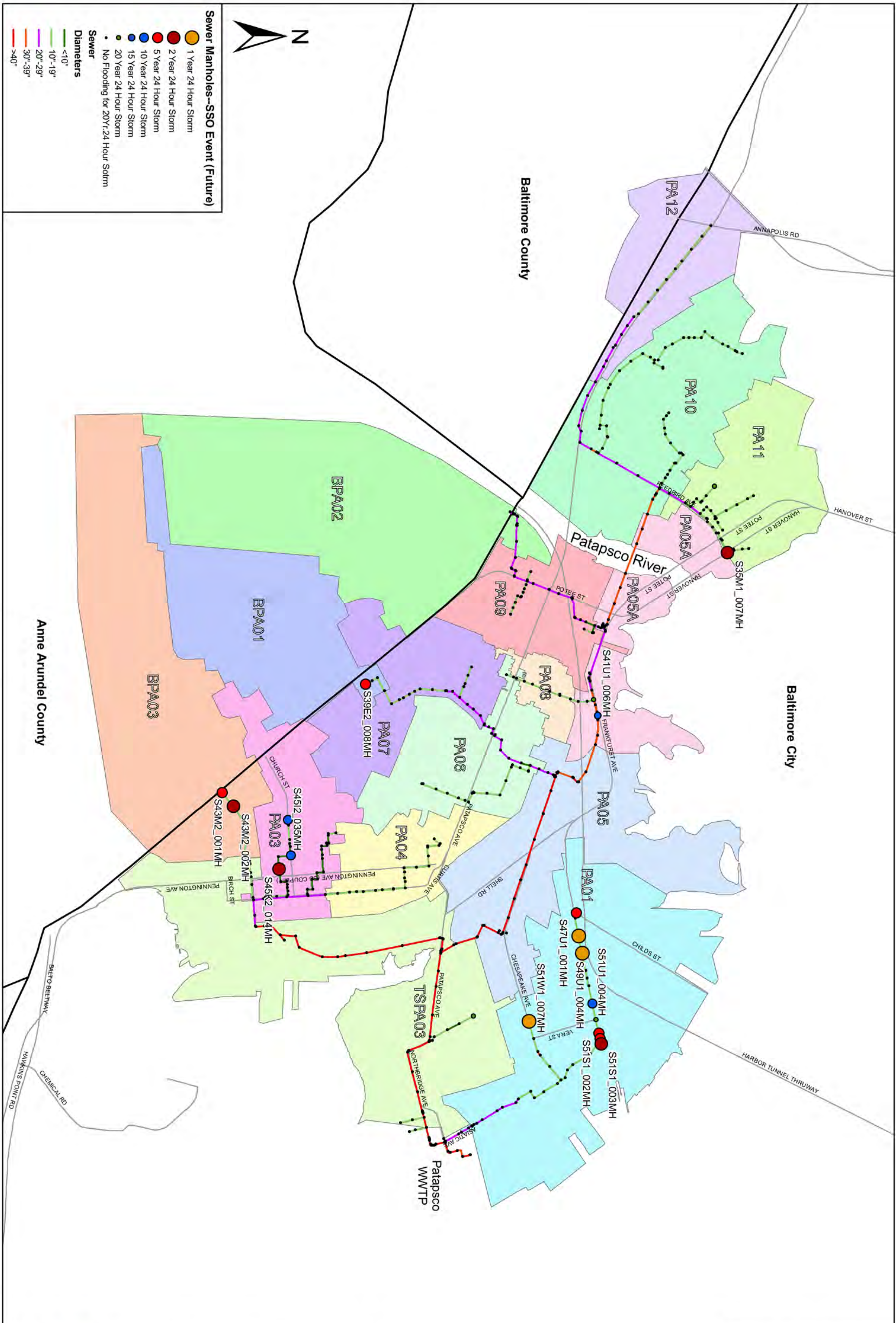

FIGURE 4.3.2

STEPHANIE RAWLINGS-BLAKE MAYOR

Project 1041 - Patapsco Collection System Evaluation & Sewershed Plan

Wet Weather Event Future Conditions Return Period Analysis

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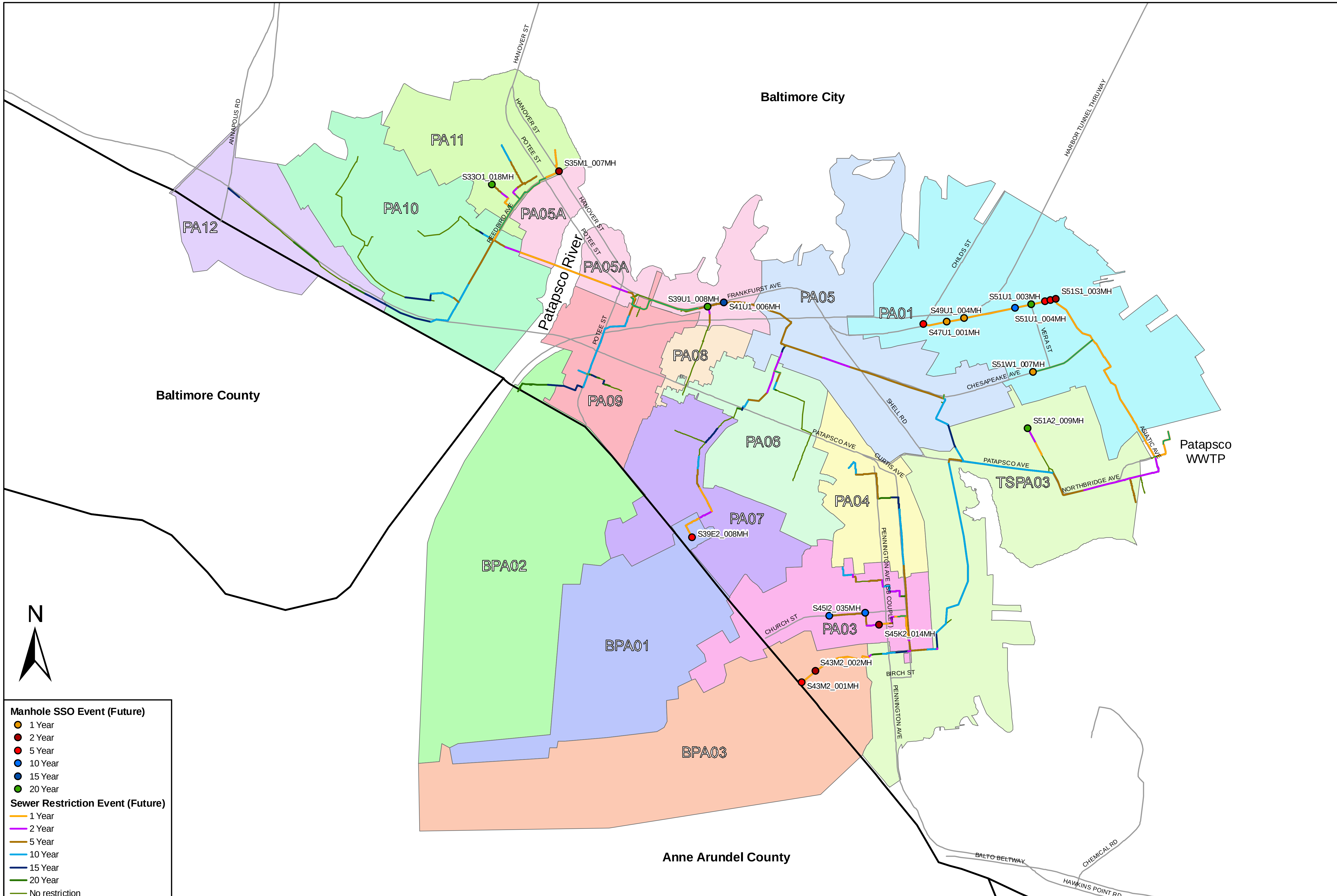
February 2010

1 inch equals 2,000 feet

Wet Weather Event Future Conditions Hydraulic Restrictions Analysis

February 2010
1 inch equals 2,000 feet



Project 1041 - Patapsco Collection System Evaluation & Sewershed Plan

FIGURE 4.3.6